Art. XII.—*Account of the Telegraphic Determination of the Difference of Longitude between Melbourne and Hobart Town in the Year* 1875.

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The late transit of Venus having been successfully observed at Hobart Town by the American party under the command of Professor Harkness, it became a matter of necessity to obtain the longitude of the observing station. Instead of an absolute determination with reference to the meridian of Greenwich, which would have required months, or even years, for its successful execution, Professor Harkness resolved to obtain it differentially from Melbourne, the two places being connected by means of the land lines and submarine cable of the electric telegraph; and for the purpose of arranging a scheme for carrying out this intention he visited Melbourne towards the latter end of November, 1874. Having settled upon a plan of operation with Mr. Ellery, and having obtained the consent and promise of hearty co-operation of Mr. Warren, the managing engineer of the Tasmanian Cable Company, and Messrs. James and Payter, the Melbourne managers of the electric telegraph, he returned to Tasmania, and immediately after he had observed the transit of Venus a few unsuccessful attempts were made to send the signals direct, with automatic repeaters, between Melbourne and Hobart Town. Soon after this, Professor Harkness had to accompany the "Swatara" during her cruise in the South Pacific, to collect the different parties of American observers in that part of the world, and further attempts were deferred till his return. Advantage was taken of the interval to improve the repeating apparatus, and on his return at the end of January the signals were transmitted without any difficulty.

At Hobart Town the observations were taken by Professor Harkness, who employed a portable transit instrument of 2½ inches clear aperture and 30 inches focal length, with a magnifying power of 60 diameters. The transit was reversed each night near the middle of the observations. Three clock stars and two azimuth stars were observed in each position of the axis, and from the complete set of ten stars equations of condition were formed, the solution of which by the method of least squares gave the most probable values of the collimation, azimuth, and clock errors, the level error having been previously found by means of the striding level. The positions of the azimuth stars are taken from the Melbourne General Catalogue for 1870, and those of the clock stars from a specially prepared list. The places of these latter stars differ slightly from their places as given in the *English Nautical Almanac;* the resulting clock errors are, however, generally within one-hundredth of a second of what the latter places would produce.

At Melbourne I observed with the transit circle, which has an aperture of 5 inches and a focal length of 6 feet; the eye piece used has a magnifying power of 167 diameters. This instrument does not admit of reversal, but the collimation error is found according to Bessel's method, with two collimators. The level error is obtained by means of reflection from a surface of quicksilver, and the azimuth error is found from the transits of circumpolar stars in the ordinary way, one star being generally observed above the pole and another below.

At both places self-recording chronographs were employed; that of Professor Harkness was a barrel one, regulated by a vibrating spring. The timepiece which marked the seconds on the chronograph sheets, and which transmitted the signals through the telegraph lines to Melbourne, was a box chronometer, No. 1520, by T. S. & J. D. Negus, of New York, the going of which quite justifies the fame enjoyed by those celebrated makers. The Melbourne clock was the famous Frodsham, No 991, which continues to perform as well as it did some years ago, when its going was declared to be the most remarkable for accuracy on record. It is attached to a chronograph by Siemens and Halske, of Berlin, which registers on a fillet of paper, the motion of which is governed by means of a Froude's fly.

The usual practice was to commence observing a set of stars soon after sunset; and as soon as the telegraph lines were clear from their ordinary work, the Hobart Town clock was made to transmit its time to the Melbourne chronograph, on which the Frodsham clock marked its seconds at the same time. After this the Frodsham clock sent its time to the Hobart Town chronograph, where it was registered simultaneously with the Negus chronometer. Now, taking the results as recorded on the Melbourne chronograph, and correcting them for the clock errors as determined from the star observations, the difference between the times will represent the difference of longitude *minus* the time of transmission, *plus* the difference of personal equation of the observers. On the other hand, the Hobart Town results will exibit the difference of longitude, *plus* the time of transmission, *plus* the difference of personal equation. On taking, then, half the sum of the two quantities, we shall get the difference of longitude freed from the transmission time, but still affected with personal equation. And half the difference of the quantities will give the time of transmission. The effect of personal equation could be eliminated by the observers exchanging their stations; but as that would have been attended with great inconvenience, the difference of personal equation was directly obtained on several occasions during Professor Harkness's visit to Melbourne. The method adopted for this purpose was for both observers to determine the error of the Melbourne transit clock on the same evening, selecting the stars in such a way that the mean epoch of each observer would be so nearly alike as to give the personal equation free from the influence of the rate of the clock. The following is an abstract of the results:—

COMPUTATION OF THE PERSONAL EQUATION.

Date, Melbourne Mean Time, 1874 & 1875.	Observer.	N. of Stars.	Mean of Times of the Corrected Transits.	Observed Clock Corrections.	Adopted Correction for Clock Rate.	H − W Reduced to the same Epoch.	Weight.	Product.
d. h. m.			h. m.	s.	per diem. s.	s.		
Nov. 17 9 6	H	5	0 51	− 30·921	− 0·26	+ ·125	55	6·875
9 25	W	5	1 10	31·049				
Feb. 23 8 15	H	7	6 27	32·113	+ 0·36	+ ·171	77	13·167
8 34	W	7	6 46	32·280				
26 8 43	H	6	7 7	31·078	+ 0·30	+ ·171	66	11·286
8 35	W	6	6 59	31·251				
27 8 20	H	6	6 47	30·718	+ 0·29	+ ·242	60	14·520
8 25	W	5	6 52	30·959				
							258	)45·848
Adopted Personal Equation					H − W			+ ·178

COMPUTATION OF THE DIFFERENCE OF LONGITUDE.

Date, 1875.	Difference of Longitude. Hobart Town Register.	Difference of Longitude. Melbourne Register.	Double the time of Transmission.	Number of Clock Stars Observed. H	Number of Clock Stars Observed. M	Weight.
	m. s.	m. s.	s.			
Jan. 30	9 25·996	9 25·762	0·234	7	8	392
Feb. 1	26·084	25·900	·184	6	6	315
2	25·720	25·551	·169	0	8	0
4	26·193	26·000	·193	6	6	315
5	25·935	25·609	·326	7	0	0
6	25·774	25·423	·351	6	9	378
7	25·820	25·577	·243	6	8	360

The weights are proportional to the quantity found by multiplying the number of stars observed by one observer by the number observed by the other, and dividing the product by their sum. On February 2nd no stars were observed at Hobart Town, and on February 5th no stars could be observed at Melbourne, so the difference of longitude marked in the columns has been found by carrying on the rates of the chronometer and clock respectively; as the combination weights, however, are nothing, they will not influence the final results. The transmission times, however, are independent of the rate of the clock, except for the few minutes intervening between the receipt of the set of signals; these nights, therefore, have equal weights for this purpose with the others. Carrying out the combination we get 9m. 25·841s., from this is to be subtracted 0·178s. for personal equation; we then get for the final difference of longitude 9m. 25·66s. $\pm$ ·06s., and for the mean time of transmission we get 0·121s. Taking the length of the land lines and cable at 420 miles, this would represent a speed of only 3360 miles per second; the actual speed, however, must have been considerably greater than this, for the above quantity, 0·121s., includes also the armature time of the relays and repeating apparatus. From some measures made of the speed of the current on the land lines during the determination of the difference of longitude between Melbourne and Sydney in

1868 we found the velocity on the land line to be 15,400 miles per second.

Professor Harkness's temporary Observatory in Hobart Town was situated in the Barrack-square in latitude 42° 53′ 24·6″ south, and by applying the above difference to 9h. 39m. 54·8s., the longitude of Melbourne, we get 9h. 49m. 20·46s. for the longitude of his station, which is marked by a pier, which the Tasmanian authorities have promised to preserve. Mr. Ellery has written to the Surveyor-General at Hobart Town for the situation of this pier, with reference to Fort Mulgrave, from which the longitude of the city has been hitherto reckoned; but as no reply has been as yet received, I cannot say how this new determination of longitude will agree with the old one. As a final result we have then—

Pier in Barrack-square.

Latitude	42°	53′	24·6″	South.
Longitude	147	20	6·9	East of Greenwich.

NOTE.—Since the above was written a letter has been received from Prof. Harkness, giving the results of his triangulation in Hobart Town, according to which, adopting the above position of the Pier in Barrack-square, the positions of the following places will be as under:—

	Lat.	Long.
Flagstaff at Prince of Wales Battery (Fort Mulgrave)	42° 53′ 22·3″	147° 20′ 36·3″
Flagstaff at Queen's Battery	42 52 44·0	147 20 38·8
Centre of front of St. David's Cathedral ...	42 53 6·9	147 20 10·2
